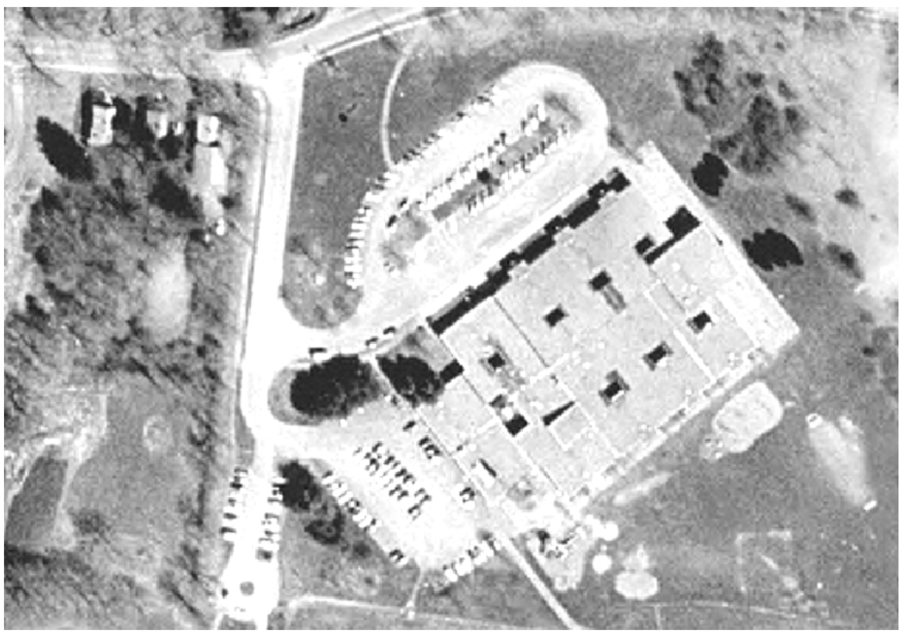
INDOOR AIR QUALITY ASSESSMENT

Wildwood Elementary School
71 Strong Street
Amherst, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
July 2004

Background/Introduction

At the request of James Robinson, School Nurse, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Wildwood Elementary School (WES), 71 Strong Street, Amherst, MA. The school experienced mold colonization of ceilings and carpets during the hot, humid weather of August 2003. Concerns about lingering effects of mold contamination and general indoor air quality prompted the request. On March 5, 2004, a visit to conduct an indoor air quality assessment was made by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA. Mr. Feeney was accompanied by Mr. Robinson during the assessment.

The school is a single story brick/concrete building constructed in 1970. The school was designed to have an open classroom plan, with clusters of four classrooms located in a "pod". Floor-to-ceiling dividers partition each pod into classrooms. There are six pods within the building. The building has a number of interior courtyards. The building also contains a library, cafeteria, kitchen and office space. A gymnasium is located in the north section of the building.

Methods

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds

(TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school has approximately 423 students in kindergarten through sixth grade and a staff of approximately 100. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in two out of fifty areas surveyed, indicating adequate air exchange in the majority of areas of the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were operating in classrooms throughout the school. Obstructions to airflow, such as plants and boxes on top of air diffusers or furniture in front of univent returns, were seen in some classrooms. In order for univents to provide fresh air as designed, air diffusers and return vents must remain free of obstructions.

Fresh air is provided to interior areas by rooftop air handling units (AHUs) that are connected to wall or ceiling-mounted air diffusers via ductwork. Fresh air for these AHUs is drawn from the courtyard through fresh air intakes on exterior walls. As with the univents, the AHUs were operating during the assessment.

Exhaust ventilation is provided in pods by an exhaust vent located between restrooms, at the farthest point from the hallway (Picture 1). This configuration uses the classroom areas and space between dividing walls as a large duct to exhaust air from the entire pod. Activation/deactivation of the exhaust ventilation is controlled by a switch located in one of the pod restrooms (Picture 2). The exhaust ventilation in pod C was deactivated and could not be reactivated using the restroom switch, indicating either damage to the switch or the deactivation of a circuit breaker. The exhaust vent in one pod was blocked with stored materials. In order to function properly, these vents must be activated and remain free of obstructions.

Exhaust ventilation in other areas is provided by wall mounted exhaust grilles. In some areas, these exhaust vents are located behind hall doors (Picture 3). When opened, the hallway door blocks the vent, limiting the ability of the ventilation system to exhaust air. To ensure proper operation of the ventilation system, hallway doors in these areas should remain closed during occupancy.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The last balancing of these systems was reportedly performed in 1999.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 65^{o} F to 78^{o} F, which were below the BEHA recommended comfort guidelines in some areas (Table 1). The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in the building was below the BEHA recommended comfort range in all areas surveyed. Relative humidity measurements ranged from 25 to 37 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As reported by Amherst school and health officials, the school had experienced mold colonization of carpets and ceiling tiles during August 2003. The New England area experienced hot, humid weather that persisted for more than 14 days during August 2003 (The Weather Underground, 2003). As a result, materials in many schools and buildings were moistened for an extended period. Relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). In the experience of BEHA staff, excessively humid weather can provide enough airborne water vapor to create adequate conditions for mold growth in buildings. In general, materials that are prone to mold growth can become colonized when moistened for more than 24 to 48 hours.

BEHA staff evaluated the WES for the presence of water damaged materials, visible mold colonies and musty odors. Water damaged ceiling tiles were noted in three areas of the building (Table 1) and a musty odor was detected in the faculty workroom located at the center of the building. The musty odor in this room was traced to a box of paperback books stored on a counter (Picture 4a and 4b). A pungent, musty odor was noted when a book was opened, indicating possible mold colonization of the glue/paste of the book spine or paper. Ventilation alone cannot serve to reduce or eliminate mold growth in these materials. These books will continue to be a source of mold associated particulates. As an initial step, options concerning the preservation of materials stored in this area should be considered. Porous materials that do not warrant preservation, restoration or transfer to another media (e.g., microfiche or computer scanning) should be discarded. Where stored materials are to be preserved, restored or otherwise handled, an evaluation to determine the feasibility of preservation should be conducted by a professional book/records conservator. This process can be rather expensive and may be considered for conservation of irreplaceable documents that are colonized with mold. Due to the cost of book conservation, disposal or replacement of moldy materials may be the most economically feasible option.

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

The HVAC system has the capacity to provide air conditioning during warm weather. Each univent is equipped with a pan/condensation drain system to collect condensation from cooling coils. When warm, moist air passes over the cooling coils, condensation can form. Condensation is the collection of moisture on a surface at or below the dew point. The dew point is the temperature that air must reach for saturation to occur. Over time, condensation can collect and form water droplets. Water can then drip from the suspended surface. For this reason, drainage systems to collect condensation are installed beneath cooling coils in HVAC systems. Select univent drip pans were examined. All were found to have debris accumulation (Picture 5), which can serve as a mold growth medium. In addition, plant debris appears to have accumulated at the base of the univents, near the fresh air intakes. If repeatedly moistened, this material can also serve as mold growth media.

Of note is the wall-to-wall carpeting in classroom areas, which is installed against the threshold of exterior doors (Picture 6). Water damage to the doorframes indicates that carpeting installed around the threshold may become moistened regularly, most likely during wind–driven rain or drifting snow. The gutter system is designed to direct rainwater to roll down the exterior wall, collect at the base and drain away from the building. This design is problematic because tarmac/cement slabs used as exterior door thresholds cause the rainwater to splash. Splashing rainwater can lead to chronic moistening of the exterior wall and doors, which in turn moistens carpet installed against the doorframe. Mold colonization of the carpet can occur from repeated moistening. As discussed, if porous materials (e.g., carpeting) are not dried within 24-48 hours, mold growth may occur.

Plants were observed in several classrooms. Plant soil and drip pans can serve as sources of mold growth. Plants should also be located away from univents to prevent aerosolization of dirt, pollen or mold. Two aquariums were observed in the building. Aquariums should be properly maintained to prevent bacterial/mold growth and nuisance odors.

Shrubbery in direct contact with the exterior wall brick was noted in several areas around the building. Because of proximity and growth of roots and branches directly against the building, shrubbery can serve as a possible source of water impingement on the exterior curtain wall. Plants retain water and, in some cases, can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth. One classroom had a garden located near the univent fresh air intake (Picture 7). As discussed, plants can be a source of pollen and/or mold that can be drawn into the air intake and distributed via the univent.

Other Concerns

Indoor air quality can also be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The US Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) for exposure to carbon monoxide in outdoor air. The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter. ASHRAE has adopted the NAAQS as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the USEPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. *Carbon monoxide should not be present in a typical, indoor environment*. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non detectable (ND). Carbon monoxide readings in the school were also ND (Table 1).

The US EPA also established NAAQS for exposure to particulate matter. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average. These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standards requires outdoor air particle levels be maintained below 65 μg/m^3 over a 24-hour average. Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 44 μg/m^3. PM2.5 levels measured indoors ranged from 3 to 66 μg/m^3 (Table 1). Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors. The highest PM2.5 level measured in the school (66 μg/m^3) was measured in cafeteria 3. This measurement may be attributed to combustion products created during cooking of meals.

Indoor air quality can also be negatively influenced by the presence of materials containing VOCs. VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school. The faculty workroom contains equipment that can be a source of odors and irritants. Two photocopiers are located in the workroom cul-de-sac. The closest exhaust vent to this area is located on an interior wall next to the computer room (Picture 9). This vent draws photocopier pollutants from the cul-de-sac and into the hallway. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). In addition, this area also contains a laminator machine, which can be a source of odors and waste heat.

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and cleaners may contain VOCs (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were found in a number of classrooms and insecticides have reportedly been brought in by individuals. Cleaning products and insecticides contain chemicals that can be irritating to the eyes, nose and throat and should be kept out of reach of students.

A pungent, acrid odor was noted in the music room. An air purifier (Biozone 2000 Room Air Purifier) was operating within this room (Pictures 10a and 10b). The Biozone 2000 Room Air Purifier is an ozone generating air purifier (PeakPureAir.com, 2004). At this time, the efficacy of ozone as an indoor air cleaner is being examined by several government agencies. While ozone may be effective in removing some odors of biological origin (e.g. skunk), its use as a universal air cleaner has not been established (US EPA, 2003). As discussed, ozone is a highly irritating substance to the respiratory system. Until more definitive information becomes available, the use of ozone generators in occupied areas should be done with caution. Please note that the label for this device warns that it should not be "used in occupied spaces under 150 sq. ft."

A potential source for drawing in unfiltered air from the outdoors was identified. Condensation drainpipe holes were seen in the back of each univent cabinet. Each drain penetrates the rear wall of the univent cabinet and exits the building through the exterior of the univent fresh air intake. Since this hole exists above the filter in univents (Picture 11), operating fans can draw in outdoor pollutants (e.g., pollen, dirt and dust), by-passing filters.

A number of classrooms contained upholstered furniture and/or throw rugs/pillows. Upholstered furniture is covered with fabric that comes in contact with human skin, which can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture and cleaning of other materials is recommended (Berry, 1994). Upholstered furniture present in schools be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

Also of note was the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, and boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or cleaned periodically to avoid excessive dust build up. In addition, a number of exhaust vents in classrooms were noted with accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles.

Stored food was noted in some classrooms. Poorly stored food and/or containers can create conditions to attract pests, such as ants into the building. Under current Massachusetts law (effective November 1, 2001), the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals that can be sources of eye, nose and throat irritation. The reduction/elimination of pathways/food sources that are attracting these insects should be the first step taken to prevent or eliminate infestation.

A pipe connected to the air handling unit in the work room storage area had insulation that consisted of an exposed white, chalky material (Picture 12). This material may contain asbestos and should be examined by a licensed asbestos abatement contractor to identify and remediate potential exposure issues with regard to this material.

Conclusions/Recommendations

The remediation efforts to remove mold contaminated material from the WES appeared to be effective. No mold contamination, significant water damage of building components or musty odors (except from books in the faculty work room) related to the hot, humid weather of August 2003 were discovered during the assessment. Some general indoor air quality issues warrant further attention. In view of the findings at the time of the assessment, the following recommendations are made:

1. Repair the exhaust ventilation system in pod C.
2. Remove all blockages from univents and exhaust vents.

3. Operate both supply and exhaust ventilation continuously during periods of school occupancy to maximize air exchange.
4. Consult a ventilation engineer concerning re-balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
6. Seal holes inside univents with rigid foil faced sheet material and water based high temperature and fiber reinforced mastic. Temporarily sealing the holes in this manner would prevent both air and moisture penetration into univents.
7. Reduce/trim or remove plants that are growing against the exterior brick curtain wall.
8. Discard moldy books and box in faculty work room.
9. Remove carpeting up to three feet from the threshold of exterior doors. Replace carpeting with a non-slip, nonporous material (e.g., rubber matting, tile).
10. Move plants away from univents in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants.
11. Move garden in Picture 7 at least five feet away from univent fresh air intake.

12. Clean accumulated debris in univent drip pans and fresh air intake vents.
13. Maintain aquariums to prevent bacteria, mold and associated odors.
14. Consider discontinuing the use of the ozone generating air purifier.
15. Examine the feasibility of installing exhaust ventilation for the photocopier area in the faculty work room.
16. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
17. Clean upholstered furniture and throw rugs/pillows on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
18. Store cleaning products properly and out of reach of students.
19. Use the principles of integrated pest management (IPM) to rid this building of pests. A copy of the IPM recommendations (MDFA, 1996) can be downloaded from the following website: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.
20. Evaluate and remediate insulation shown in Picture 12 in a manner consistent with federal and Massachusetts Asbestos remediation and disposal laws if needed.
21. Consider adopting the US EPA document, "Tools for Schools" (US EPA, 1992) as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
22. For further building-wide evaluations and advice on maintaining public buildings, refer to the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

Berry, M.A. 1994. *Protecting the Built Environment: Cleaning for Health,* Michael A. Berry, Chapel Hill, NC.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

IICR. 2000. IICR S001 Reference Guideline for Professional On-Location Cleaning of Textile Floor Covering Materials Institute of Inspection, Cleaning and Restoration Certification. Institute of Inspection Cleaning and Restoration, Vancouver, WA.

Mass Act. 2000. An Act Protecting Children and families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E.

MDFA. 1996. Integrated Pest Management Kit for Building Managers. Massachusetts Department of Food and Agriculture, Pesticide Bureau, Boston, MA.

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

PeakPureAir.com. 2004. Biozone Air Purifier's Purifying Plasma web page. Peak Pure Air.com, Jonestown, TX. *http://www.peakpureair.com/biozref.htm*.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Research Triangle Park, NC. ECAO-R-0315. January 1992.

US EPA. 2001. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html

US EPA. 2003. "Ozone Generators That Are Sold As Air Cleaners. An assessment of Effectiveness and Health Consequences". Indoor Environments Division, Office of Radiation and Indoor Air Programs, Office of Air and Radiation (6604j). Washington, DC. Available at http://www.epa.gov/iaq/pubs/ozonegen.html

Weather Underground, The. 2003. Weather History for Massachusetts, August 1, 2003 through August 13, 2003. http://www.wunderground.com/history/

Picture 1

Pod Exhaust Vent

Picture 2

Activation/Deactivation of the Exhaust Ventilation Is Controlled By a Switch Located in One of the Pod Restrooms

Picture 3

Exhaust Vents Located Behind Hall Doors

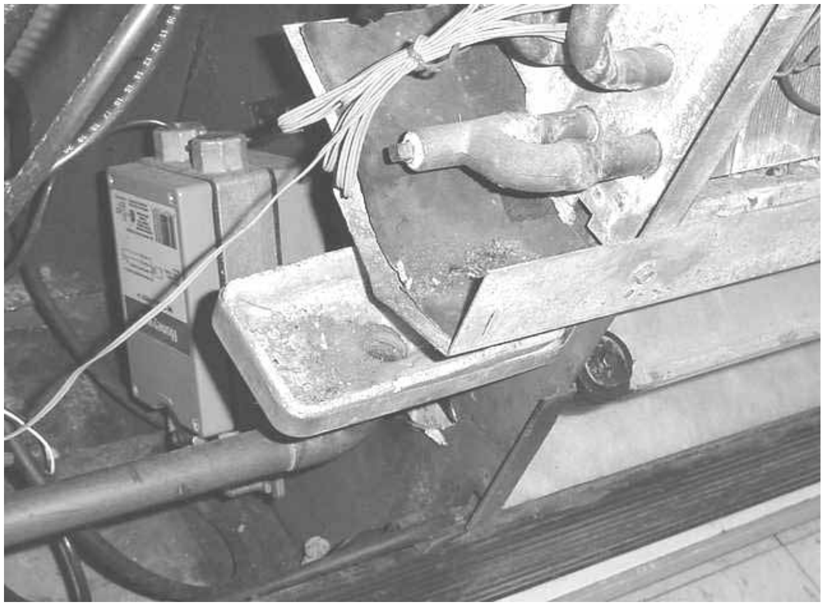
Picture 4a

Box That Was Source of Musty Odor in the Faculty Work Room

Picture 4b

Close-Up of Books in Picture 4, Note Water Stains and Possible Mold Colonies on Book

Picture 5



Univent Drip Pans with Debris Accumulation

Picture 6

Carpeting in Class Areas, Which Was Installed Against the Threshold of Exterior Doors

Picture 7

Classroom with Garden Located near the Fresh Air Intake of the Univent

Picture 8

Photocopier Cul-de-sac

Picture 9

exhaust vent

photocopier cul-de-sac

Closest Exhaust Vent to This Area Is Located On an Interior Wall Next To the Computer Room

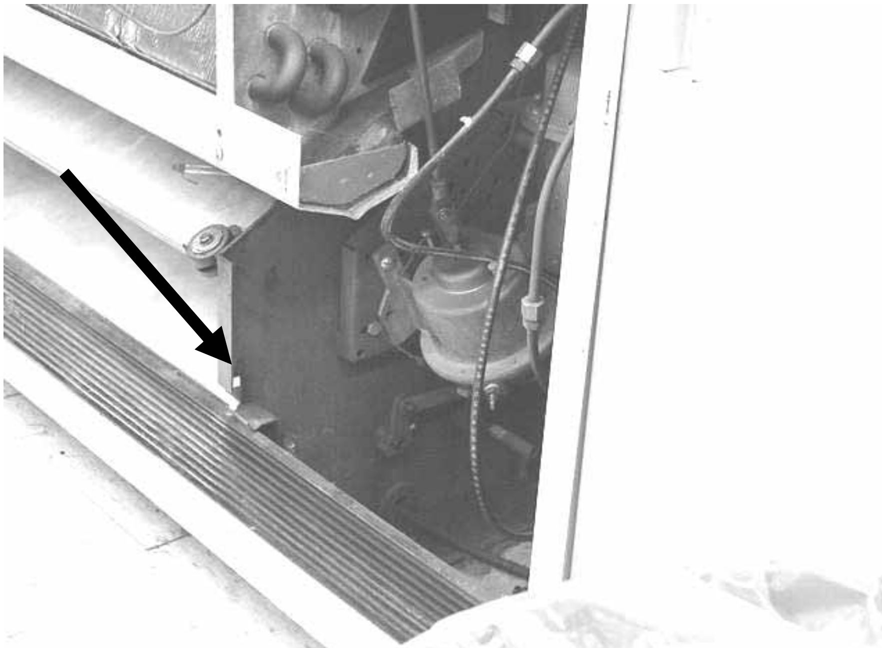
Picture 10a

Biozone 2000 Room Air Purifier

Picture 10b

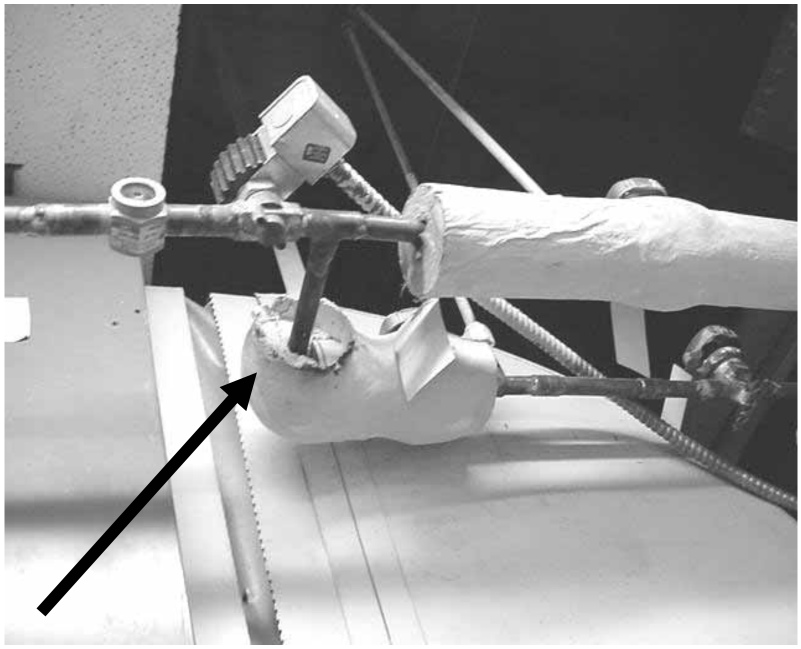
Warning Label On Back Of Biozone 2000 Room Air Purifier

Picture 11



Holes in Univent Cabinet Wall

Picture 12



A Pipe Connected to the Air Handling Unit in the Work Room Storage Area Had Insulation That Consisted of Exposed White, Chalky Material

Wildwood Elementary School **Indoor Air Results**

71 Strong Street, Amherst MA **March 5, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	49	53	338	ND	ND	44	0				
Music Room	70	30	452	ND	ND	38	0	N	Y	Y	
C4	69	31	637	ND	ND	53	12	Y	Y	Y	UF, clutter
C3	68	31	561	ND	ND	52	6	Y	Y	Y	1 WD-CT, clutter
Sheryl's Room	65	27	747	ND	ND	37	0	N	Y	Y	25 computers
Computer lab	77	28	798	ND	ND	45	12	N	Y	Y	1 WD-CT
Guidance	76	25	663	ND	ND	3		N	Y	Y	Hole in CT, HEPA filter

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
Wd = water damaged
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Wildwood Elementary School

71 Strong Street, Amherst MA

Indoor Air Results

March 5, 2004

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Rachman's Room	78	26	646	ND	ND	39	0	N	Y	Y	Ozone/Ionizer; inter-room door open
Art Room	69	31	519	ND	ND	61	2	Y	Y	Y	
Sally Crawford's Room	70	32	748	ND	ND	17	1	N	Y	Y	
Resource Room	70	32	727	ND	ND	12	0	N	Y	Y	HEPA filter
Health	70	35	848	ND	ND	39	2	N	Y	Y	Exhaust in restroom
Cafeteria 1	70	31	666	ND	ND	58	50+	Y	Y	Y	1 WD-CT, hallway door open
Cafeteria 2	72	32	737	ND	ND	52	50+	Y	Y	Y	

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Wildwood Elementary School **Indoor Air Results**

71 Strong Street, Amherst MA **March 5, 2004**

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Cafeteria 3	70	32	951	ND	ND	66	50+	Y	Y	Y	Hallway door open, univent ex
H1	72	32	721	ND	ND	54	0	Y	Y	Y	
H2	71	32	642	ND	ND	50	3	Y	Y	Y	Pile of pillows, supply blocked by plants, exhaust blocked by furniture
H3	71	31	551	ND	ND	51	1	Y	Y	Y	Exhaust blocked by furniture
H4	71	31	609	ND	ND	51	2	Y	Y	Y	UF, supply blocked by furniture, exhaust blocked by furniture
G1	69	34	740	ND	ND	48	20	Y	Y	Y	
G2	69	33	729	33	ND	46	2	Y	Y	Y	TB, ozone generator, supply blocked by plastic boxes

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G3	69	33	757	ND	ND	53	19	Y	Y	Y	
G4	69	33	770	1	ND	44	9	Y	Y	Y	Supply blocked by plants
D1	70	31	637	ND	ND	50	15	Y	Y	Y	Supply blocked by furniture
D2	71	31	515	ND	ND	48	16	Y	Y	Y	Supply blocked by plants, furniture
D3	70	27	751	ND	ND	53	14	Y	Y	Y	Food storage/use, clutter, hallway door open
D4	70	32	760	ND	ND	47	17	Y	Y	Y	UF, clutter, supply blocked by furniture
C1	70	29	551	ND	ND	49	15	Y	Y	Y	Supply blocked by plants, furniture

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A2	73	26	570	ND	ND	45	10	Y	Y	Y	Cleaners, popcorn, soda cans
Teachers' Lounge	76	26	721	ND	ND	37	1	N	Y	Y	Stove, soda cans, inter-room door open
E1	72	33	752	ND	ND	54	9	Y	Y	Y	Tub, pillows, supply blocked by plants
E2	70	33	673	ND	ND	53	17	Y	Y	Y	Cleaners, food storage/use
E3	72	31	639	ND	ND	49	4	Y	Y	Y	Clutter, supply blocked by plants
E4	73	32	535	ND	ND	50	2	Y	Y	Y	
Gymnasium	69	31	696	ND	ND	56	10	N	Y	Y	
F1	69	37	774	ND	ND	50	4	Y	Y	Y	Plants, Supply blocked by plants

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F2	69	33	693	ND	ND	52	16	Y	Y	Y	Aqua, rubber cement, supply blocked by plants
F3	69	33	619	ND	ND	59	13	Y	Y	Y	
F4	69	35	707	1	ND	59	17	Y	Y	Y	Plants, supply blocked by plants
C2 pod	69	31	540	ND	ND	50	15	Y	Y	Y	UF, Clutter, Hallway door open, supply blocked by clutter
K1	70	30	550	ND	ND	51	0	N	Y	Y	UF
K2 Early Childhood	69	30	415	ND	ND	52	2	Y	Y	Y	UF, clutter Hallway door open
K3	70	31	655	ND	ND	50	0	Y	Y	Y	UF, supply blocked by plants, furniture

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SPED	71	30	697	ND	ND	45	1	Y	Y	Y	TB, supply blocked by furniture
Conference Room	72	32	558	ND	ND	42	0	N	Y	Y	RR
Kristen Room	72	31	796	ND	ND	16	0	N	Y	Y	HEPA
Activities Therapy Rm	71	30	748	ND	ND	27	0	N	Y	Y	
Library	70	30	667	ND	ND	39	20+	N	Y	Y	UP, paddle fans in ceiling, open to hallway-no doors, 2/6 supply and exhaust blocked w/ sheet metal by to teacher
Music Room	71	29	736	ND	ND	35	0	N	Y	Y	Ozone generator on, must odor carpet, 2/6 supply blocked by sheet metal
LSH10	74	29	754	ND	ND	35	2	N	Y	Y	PF on, clutter, HEPA filter, Lysol wipes, hallway door open

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Teachers' Work Area	76	25	655	ND	ND	33	2	N	Y	Y	Clutter, laminator, 2 PC, moldy books, HEPA filter

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